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Abstract

RESEARCH WITH INELASTIC NEUTRON SCATTERING AT THE NRU REACTOR

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1. Four spectrometers have been in use at the NRU reactor for several years for the study of liquid- and solid-state phenomena by inelastic neutron scattering. Two are crystal spectrometers which define the energies of the incoming and scattered neutrons by Bragg reflection from single crystals. The other two use pulsed beams and time-of-flight techniques.

2. The triple-axis crystal spectrometer allows automatic variation of incoming and outgoing neutron energies, angle of scattering, and specimen orientation. With this spectrometer it is possible to measure the energy distribution of scattered neutrons while maintaining the (vector) momentum transfer constant. A second crystal spectrometer, designed by D.G. Henshaw for investigations of liquid helium, combines such features as a 400-cm^2 beam, high resolution, and low background conditions.

3. The time-of-flight machines are of two types. The first (designed by P.A. Egelstaff) employs a high-precision phased-chopper system to give a pulsed monoenergetic beam of neutrons. The energies of the scattered neutrons are determined from their times of flight to one of many scintillation detectors covering a large range of scattering angles. The second time-of-flight machine uses a spinning single crystal to give the monoenergetic incident neutrons; it has mostly been used for work at long wavelengths and high resolution.

4. Four principal fields of study have been explored using these instruments:

- lattice vibrations in solids,
- atomic and molecular motions in liquids,
- spin-wave spectra in magnetic materials,
- inelastic neutron scattering cross-sections of interest for reactor-spectra calculations.

5. The investigations of crystal dynamics have been principally concerned with determination of the frequency/wave-vector dispersion relation $\nu(\vec{q})$ for the normal modes of vibration. Among the substances so studied are metals (lead, sodium, niobium, molybdenum, tantalum and tungsten), an alloy (β-brass), semiconductors (germanium, silicon and gallium arsenide), insulators (sodium iodide and potassium bromide) and miscellaneous materials such as pyrolytic graphite and strontium titanate.

6. Extensive experiments on atomic motions in water were made at several different temperatures. Liquid bromine, liquid lead, liquid tin, liquid argon and liquid helium have also been investigated; the experiments on helium were carried out with high resolution for the purpose of determining accurately the shape of the Landau excitation curve below the λ transition temperature, whereas the experiments on lead and bromine were carried out over a large range of energy and momentum transfers to obtain a general picture of the molecular motions.

7. The experiments on magnetic systems have been chiefly concerned with the determination of the energy/wavelength dependence of spin waves in cobalt (with 8% iron) and in magnetite. Other experiments have been designed to obtain information about specific magnetic levels in materials such as ytterbium iron garnet and rare-earth oxides.

8. Inelastic scattering cross-sections have been measured over a wide range of energy and momentum transfer, and attempts have been made to deduce the main features of the frequency-distribution function $g(\nu)$ from the results. Beryllium, beryllium oxide, graphite, uranium oxide and many hydrogenous compounds are among the solids studied.